Tegmina obscurely and finely punctured; wings dark fuscous with the nervures black. Hind tibiæ with a small spine towards apex.

♀. Long. ex. tegm. 17 mill. Exp. tegm. 45 mill.
Greatest long. pronot. 7½ mill. Exp. lat. ang. pronot. 11 mill.

Habitat, Taoo, Tenasserim. Alt. 3—5000 ft.

Explanation of Plate II.

Fig. 1. *Sminthus marginellus*, Dist.
„ 2. *Platypleura insignis*, Dist.
„ 3. *Huechys thoracica*, Dist.
„ 4. *Cryptotympana recta*, Walk.
„ 5. *Cosmoscarta tricolor*, St. F. and S. var.
„ 6. „ *masoni*, Dist.

IV.—*On the Diurnal Variation of Rainfall Frequency at Calcutta.*—By Henry F. Blanford, F. G. S., F. Z. S., F. M. S.

(With Plate III.)

[The greater part of the following paper was written some months since in France, and laid before the Society at its meeting in November 1878. In the original paper, the registers of only six years were discussed; but inasmuch as those for twenty years are available in the Meteorological Office, on my return to India, with the permission of the Council, I have withdrawn and recast the paper, including in the data the whole of the existing registers. As might have been anticipated, the inclusion of a period more than three times as long as that originally treated of, has had the result of clearing away some irregularities, and of bringing out more distinctly the true character of the variation; some of the minor features of which were but doubtfully indicated in the original restricted table; while the more prominent features have been confirmed and emphasised. With a view to their more ready appreciation, a plate has been added, which will enable the reader to compare the diurnal variation of rain frequency at different seasons, with the normal diurnal variations of pressure, temperature, relative humidity and vapour tension at Calcutta. H. F. B.]

The tables here summarised are based on the hourly observations recorded at the Surveyor General's Office from August 1856, to March 1877*; during the greater part of the period on the autographic traces of an Osler's anemometer. The form of the reduction does not show the quantity of the rainfall, but only the fact of its occurrence at the several hours specified; in other words, its comparative frequency; and it is possible that the two kinds of variation may not strictly coincide. The traces in question have not yet been reduced for quantity, otherwise than for the total diurnal fall; but the laws of diurnal variation in point of frequency are so salient and decided, that it is hardly likely that any conclusions to which they may lead,

* As published in the Society's Journal.

bearing on the causes that determine precipitation will require serious modification, when the quantity of precipitation is also taken into account. This investigation, I hope to enter upon when the completion of other more pressing matters shall allow of my taking up the enquiry. Meanwhile, the present will, I think, be found a not unimportant contribution to Meteorological Science.

Table showing the Number of Hours in which rain was recorded during 21 *years at Calcutta.*

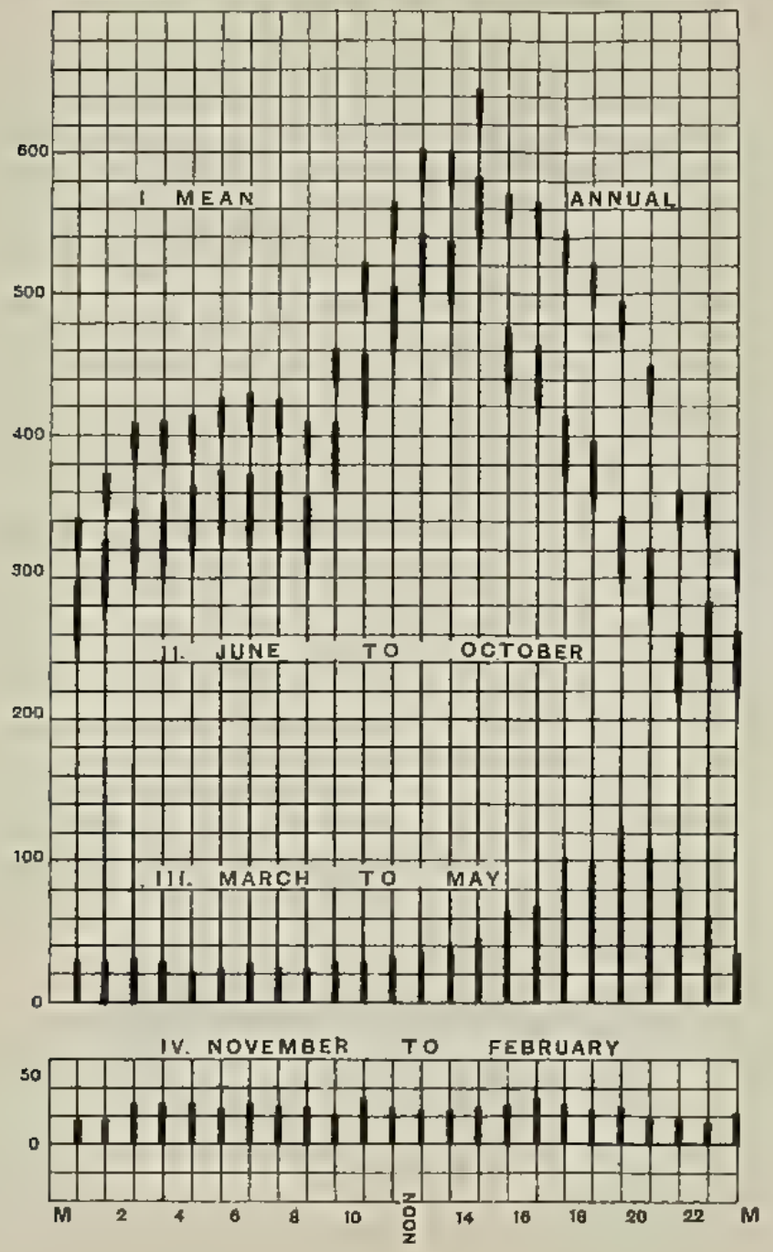
HOURS A. M.

	Midn. to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to Noon.	Midn. to Noon.
January,	3	3	5	8	9	8	8	7	8	8	11	10	88
February,	9	9	14	10	11	7	9	12	9	6	13	6	115
March,	7	9	11	8	4	5	7	9	9	11	6	8	94
April,	9	6	7	8	5	5	7	5	5	6	5	5	73
May,	12	14	14	12	12	14	14	11	10	13	18	20	164
June,	65	68	64	55	70	70	73	75	63	81	88	95	867
July,	80	92	94	88	82	95	88	97	102	114	121	135	1188
August,	97	94	94	112	107	109	105	102	103	107	124	133	1287
September,	36	47	65	64	68	57	65	55	48	72	83	86	746
October,	20	26	31	34	37	45	42	44	41	36	42	56	454
November,	2	3	6	8	6	8	8	8	8	6	10	9	82
December,	3	3	4	3	3	3	4	1	3	1	1	2	31
Yearly Total,	343	374	409	410	414	426	430	426	409	461	522	565	3189

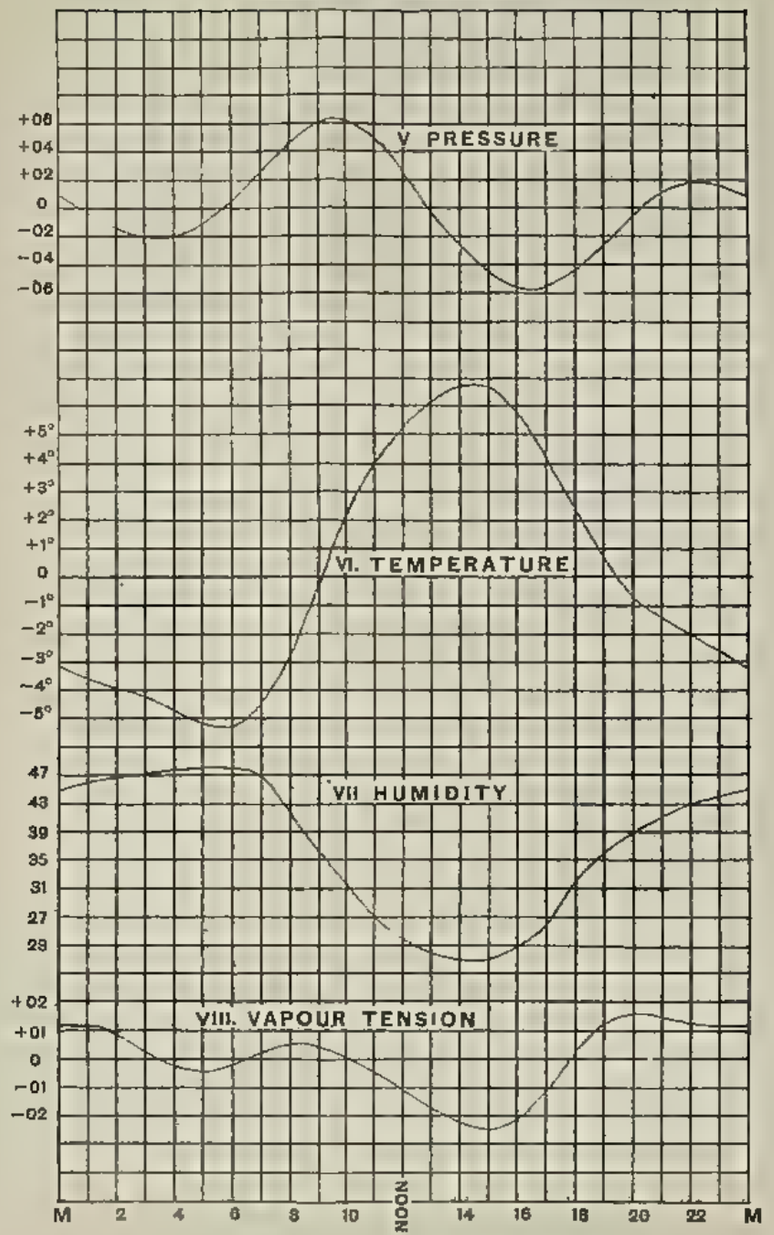
HOURS P. M.

	Noon to 13	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18	18 to 19	19 to 20	20 to 21	21 to 22	22 to 23	23 to Midn.	Noon to Midn.
January,	5	5	6	6	11	9	6	4	5	5	4	6	72
February,	7	9	7	13	9	9	10	13	8	10	9	8	112
March,	6	7	9	18	18	23	23	28	22	14	12	9	184
April,	7	5	11	25	25	26	24	33	30	23	11	9	229
May,	23	26	27	23	31	53	52	64	57	44	38	16	454
June,	101	89	96	74	83	86	88	86	85	67	66	59	980
July,	152	150	140	119	118	103	100	93	85	56	65	60	1241
August,	126	140	142	119	109	112	91	70	71	77	81	84	1222
September,	107	103	130	116	107	80	80	64	49	36	44	35	951
October,	57	55	64	49	47	32	38	30	31	25	26	25	479
November,	11	10	11	7	8	9	7	7	4	4	4	6	88
December,	1	1	3	2	5	2	2	3	2	0	0	2	23
Yearly Total,	603	600	646	571	566	544	521	495	449	361	360	319	6035

DIURNAL VARIATION OF RAIN FREQUENCY.



DIURNAL VARIATION



Photozincographed at the Surveyor General's Office Calcutta

From this table, the following conclusions may be drawn. On the average of the year, which average is mainly determined by that of the summer monsoon months, the hour at which rain is least frequent is shortly before midnight, and that at which it is most so, from 2 to 3 P. M. The latter accords approximately with the diurnal epoch of maximum temperature [see Plate III, fig. 6], but the former does not accord with its minimum; and, indeed, the frequency of rain at the hour of mean minimum temperature is nearly 40 per cent. greater than at midnight, while at the hour of its maximum it is only twice as great; and it would rather appear that while the greatest heat coincides with a principal maximum of rainfall, the greatest cold coincides with a secondary maximum. The course of variation as shewn by the table and by fig. 1 of the plate is somewhat as follows:

For about three hours after midnight, the frequency of rainfall increases rapidly, but after 3 A. M. more slowly, till about sunrise; after which there is a slight falling off to a secondary minimum at 9 A. M. This is very distinctly shown in the present table: in that originally drawn up it was less clearly indicated. After 9 A M. the frequency increases rapidly to the absolute maximum between 2 and 3 P. M. From this maximum it declines, without interruption, to the minimum before midnight. The total number of rainy hours from midnight to noon is 46 per cent. of the whole; and between noon and midnight 54 per cent. On the other hand, in the day time (6 A. M. to 6 P. M.), the proportion is 57 per cent., and 43 per cent. in the night hours.

The character of the variation in the rainy months of the summer monsoon does not differ materially from the above. But that of the hot season is very different; and that of the cold season again differs from both and is more uniform than either. The following table and figs. 2, 3 and 4 in the Plate exhibit the data thus arranged according to the three seasons.

	Hours A. M.											
	Midn. to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to Noon.
Rains: June to October,	298	327	348	353	364	376	373	373	357	410	458	505
Hot season: March to May, ...	28	29	32	28	21	24	28	25	24	30	29	33
Cold season: November to February, ...	17	18	29	29	29	26	29	28	28	21	34	27

	Hours p. m.											
	Noon to 13	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18	18 to 19	19 to 20	20 to 21	21 to 22	22 to 23	23 to Midn.
Rains : June to October,	543	537	572	477	464	413	397	343	321	261	282	263
Hot season : March to May,	36	38	47	66	69	102	99	125	109	81	61	34
Cold season : November to February,	24	25	27	28	33	29	25	27	19	19	17	22

The variation in the rainy months is, then, almost identical with that above described, the chief difference being that after the afternoon maximum, the decline is more rapid. The heavy rains of the monsoon months are, then, more particularly rains of the day time, favoured and accelerated by the diurnal rise of temperature, and declining with the decline of the sun's heat. In a nearly saturated atmosphere, the rapidity with which vapour ascends from lower to higher levels, and eventually becomes dynamically cooled and condensed, depends on the temperature, increasing indeed as the square of the absolute temperature. The relative humidity of the lower atmosphere (as tested in our observations), does not follow the same course of variation. Indeed, as may be seen in fig. 7, this course is exactly the inverse of that of temperature, but as far as can be judged from casual observation, the formation and dispersion of *cumulus* cloud, indicating the state of saturation at heights of from 2000 to 7000 or 8000 feet, is equally determined by the rise and fall of the temperature, and in its mode of formation the rain-cloud of the summer monsoon is essentially *cumulus*. The hour of least frequent rainfall, which in the summer monsoon would seem to be between 10 and 11 p. m., is probably also that of least cloudiness. The horary variation of cloud is not known for Calcutta, but I found some time since on examining the registers of a number of Bengal stations, at which the cloud proportion had been recorded for some years at 4 and 10 a. m. and p. m. that the average at 10 p. m. was very considerably below that observed at other hours. Kreil has noticed a similar fact at Vienna, and Neumayer in his discussion of the Observations of the Flag-Staff Observatory at Melbourne, also finds that, on the average of the year, there is a strongly marked minimum about this hour. Kreil explains this tendency to the dispersion of cloud, after sunset, by the compression which the lower atmospheric strata undergo, in consequence of the general contraction and subsidence of the mass; to which action he also refers the coincident baro-

metric rise and maximum. In any case, this coincidence of minimum raininess, minimum cloudiness and the semi-diurnal maximum of pressure, is an important fact of observation.

The rapid rise of rain-frequency after midnight corresponds, though less exactly, to the nocturnal fall of pressure; but, as on the average of the year, the secondary maximum is not reached till some time after sunrise, *viz.*, about 6 A. M. In the Melbourne curve of cloud variation, this is also about the epoch of the diurnal maximum, and as already remarked it is that of minimum temperature and maximum humidity at the ground surface. The slight fall that ensues continues till between 8 and 9, which is about an hour in advance of the epoch of maximum pressure. It would seem therefore that the tendency to the precipitation of rain is a somewhat complex function of the temperature and pressure variations; or inasmuch as the latter is an effect of the former, of the temperature variation producing two conditions which are in part mutually antagonistic in their effect on the rainfall. To sum up the results of this discussion, I would suggest the following as a possible explanation of the rainfall variation. The cooling of the atmosphere after 3 P. M. in the first place checks the production and ascent of vapour, as well as of convective atmospheric currents, and (adopting Kreil's explanation of the barometric tides) causes a rise of pressure in the lower atmosphere as a consequence of the sinking and compression of the atmospheric mass. These effects bring about a dispersion of cloud and a fall of rainfall frequency from the absolute maximum to the absolute minimum of the 24 hours. About 10 P. M. the compression having reached its maximum, re-expansion sets in, and, in conjunction with continued cooling, raises the relative humidity of the cloud-forming strata, and consequently the tendency to the formation of cloud and rain. When the re-expansion ceases about 3 or 4 A. M., the loss of heat is still operative in the same direction, though less powerfully; but, after sunrise, the direct effect of the solar heat is to diminish cloud and rainfall, while raising the pressure of the lower atmosphere; and it is not until this increasing pressure has nearly attained its maximum, and the ascent of vapour has become sufficiently active to prevail over these first effects, that the formation of cloud* and rainfall proceed actively, and attain their afternoon maximum; this condition coinciding with the highest temperature and the greatest activity of diffusing vapour and convective currents.

This explanation, I must remark, is suggested solely by a consideration of the several coincident phenomena, and presupposes an atmosphere highly charged with vapour, such as is that of the summer monsoon. It would be impossible to predict the course of the changes *a priori*, because the several

* This is of course an assumption as regards the cloud maximum.